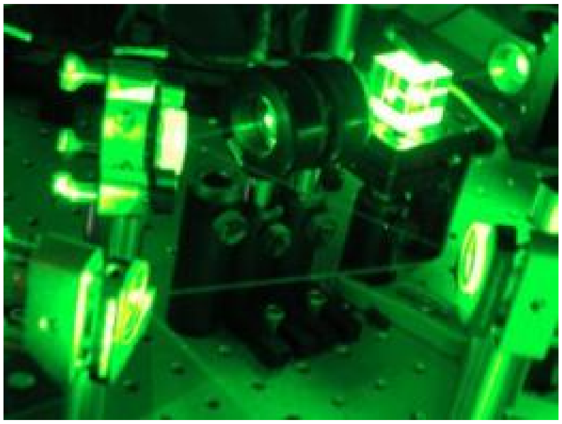
A new scheme for photonic quantum computing

October 13 2011



This is a photograph of the preparation setup for the strong green pump laser used for enhancing the nonlinearity for coherent photonic conversion. Credit: Image courtesy of IQOQI Vienna

The concepts of quantum technology promise to achieve more powerful information processing than is possible with even the best possible classical computers. To actually build efficient quantum computers remains a significant challenge in practice. A new scheme termed "coherent photon conversion", could potentially overcome all of the currently unresolved problems for optical implementations of quantum computing. The international team of scientists led by researchers from the University of Vienna introduces this new scheme this week in *Nature*.

Scientists around the world are working on the building blocks that could be linked up to create a useful quantum computer.

Single photons are at the heart of many of these schemes and, at first glance, seem like ideal information carriers: once encoded they are able to travel across galaxies and bend around suns without this information being lost.

Yet the quality that makes them such safe information carriers – the fact that they interact only very weakly with their environment – is exactly what makes them difficult to work with.

‘The problem comes when you want to create, manipulate or measure this information,’ Nathan Langford of Oxford University’s Department of Physics and the University of Vienna tells me. ‘Because a single photon doesn't interact much with atoms or other photons, it is very hard to do these things efficiently. And efficiency is the key to the whole idea of quantum computing.’

Nathan is part of a team that report in *Nature* a new way of getting round this problem: ‘The main goal of our approach, which we call coherent photon conversion, is to make photons talk to each other.’

In standard single-photon experiments a laser beam is shone into a nonlinear material. Very rarely (usually around once in every 1,000,000,000 interactions) this will cause a laser photon to split into two photons: this effectively turns the material into a random (probabilistic) photon generator. However, such randomness isn’t very helpful if you want photons to process information in a predictable manner.

So instead of a powerful laser beam the researchers examined what would happen if a single photon was shone into a nonlinear material.

‘You might expect that putting in a single photon would make it even less likely to get two photons out at the other end, but in fact we found the opposite,’ Nathan explains.

‘With a single photon input, if you make it interact with the material strongly enough, we found that it should be possible to make the probability of one photon splitting into two rise to 100% - something that is impossible with a laser input.’

What was even more surprising was that, by carefully tailoring the type of input light, the same sort of interaction with this type of material could produce many of the other essential processes needed to build a photonic quantum computer: this includes creating entanglement between two photons, and converting a weak laser beam into good single photons.

‘With our approach, it turns out that it should be possible to build a single device with four I/O ports (perhaps all on a single photonic chip) which can provide all of the building blocks required for efficient photonic quantum computing just by varying what type of light is sent into each port. This should make it much easier to build more complex designs.’

He points out that this technique isn’t limited to optical systems; it could also be used in superconducting microwave circuits and optomechanics – for example, preparing high quality phonon states in the vibrations coupling mirrors or dielectric membranes to light fields.

At the moment the work is still in the early stages: the big question is whether the efficiencies the team predict could actually be achieved.

‘So far we have focussed on a simple model of the nonlinear interaction to illustrate the basic ideas of the scheme, but now we need a more detailed model which incorporates other real-world effects, such as finite response times of the nonlinear medium and photon loss,' Nathan tells me.

'From a design perspective, we now need to identify what can be done to optimise the nonlinear coupling, both by improving the materials and engineering a better design.'

The big challenge, he says, is to move beyond eye-catching 'proof-of-principle' demonstrations of the elements required to build a quantum computer and build a device which can do something that cannot be achieved with a normal computer.

Nathan comments: 'With photons, the biggest roadblock to achieving this is still the issue of efficiency: efficiency in creating and detecting photons, as well as in manipulating them. Hopefully our work can help provide a useful step in this direction.'

More information: 'Efficient quantum computing using coherent photon conversion' N. K. Langford, S. Ramelow, R. Prevedel, W. J. Munro, G. J. Milburn & A. Zeilinger doi:10.1038/nature10463

Provided by University of Vienna

Citation: A new scheme for photonic quantum computing (2011, October 13) retrieved 23 April 2024 from https://phys.org/news/2011-10-scheme-photonic-quantum.html